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(54) [Title of the Invention]

LITHOGRAPHIC PRINTER

(57) [Abstract]

[Problem] to reduce the size of the reticle or wafer aligning stage while maintaining the function to measure the exposure light state or the imaging characteristics.

[Means for Resolution] A wafer W is put on a wafer stage WST that is arranged to move in X and Y directions over a base 13. A reticle-pattern image is printed in an exposure area 12 over the wafer W and the reticle and the wafer W are scanned in the Y direction, thereby effecting a printing. A measurement stage 14 is arranged over the base 13, to move in X and Y directions independently of the wafer stage WST. On the measurement stage 14, there is formed a spatial-image detecting system including an illumination-dosage monitor 18, an illuminance-nonuniformity sensor 19 and a measurement plate 20 formed with a slit. Because the wafer stage WST is satisfactorily provided with the minimally required functions for printing, the wafer stage WST can be reduced in size and weight.

[Claims]

[Claim 1]

A printer that transfers a pattern formed on a mask onto a substrate by use of an exposure beam, the printer comprising:

a first stage that holds at least one of the mask and the substrate and moves a predetermined area;

a second stage that is independent of the first stage; and

a measuring instrument that is attached on the second stage and measures a state of the exposure beam.

[Claim 2]

A printer according to claim 1, wherein the second stage is arranged to move independently of the first stage.

[Claim 3]

A printer according to claim 1, comprising a control unit that causes the first stage to move between a position to which the exposure beam is to be irradiated and a position to which the exposure beam is not to be irradiated.

[Claim 4]

A printer according to claim 2, comprising a control unit that causes the second stage to move between a position to which the exposure beam is to be irradiated and a position to which the exposure beam is not to be irradiated.

[Claim 5]

A printer according to claim 1, comprising a control unit

that aligns the second stage to a position to which the exposure beam is not to be irradiated when the first stage is in a position to which the exposure beam is to be irradiated.

[Claim 6]

A printer that projects a pattern formed on a mask onto a substrate through a projection optical system, the printer comprising:

a first stage that holds the substrate and moves across a predetermined area;

a second stage that is independent of the first stage; and

a measuring instrument that is arranged on the second stage and measures an imaging characteristic of the projection optical system.

[Claim 7]

A printer according to claim 6, wherein the second stage is arranged to move independently of the first stage.

[Claim 8]

A printer according to claim 6, comprising a control unit that causes the first stage to move between a position within an exposure area due to the projection optical system and a position of outside the exposure area.

[Claim 9]

A printer according to claim 6, comprising a control unit that causes the second stage to move between a position of

within an exposure area due to the projection optical system and a position outside the exposure area.

[Claim 10]

A printer that transfers a pattern formed on a mask onto a substrate by use of an exposure beam, the printer comprising:

a stage arranged with a measuring instrument that measures a state of the exposure beam; and

a cooling device that is provided on the stage and cools the measuring instrument.

[Claim 11]

A printer that projects a pattern formed on a mask onto a substrate through a projection optical system, the printer comprising:

a stage arranged with a measuring instrument that measures an imaging characteristic of the projection optical system; and

a cooling device that is provided on the stage and cools the measuring instrument.

[Claim 12]

A printer that transfers a pattern formed on a mask onto a substrate by use of an exposure beam, the printer comprising:

a first stage that holds at least one of the mask and the substrate and moves across a predetermined area;

a second stage mounted with a measuring instrument that measures a state of the exposure beam; and

a heat insulation member that is arranged between the first stage and the second stage and cuts off heat conducting from the second stage.

[Claim 13]

A printer according to claim 12, wherein the heat insulation member is of a solid material low in thermal conductivity or a gas regulated in temperature.

[Claim 14]

A printer that projects a pattern formed on a mask onto a substrate through a projection optical system, the printer comprising:

a first stage that holds the substrate and moves across a predetermined area;

a second stage mounted with a measuring instrument that measures an imaging characteristic of the projection optical system; and

a heat insulation member that is arranged between the first stage and the second stage and cuts off heat conducting from the second stage.

[Claim 15]

A printer according to claim 14, wherein the heat insulation member is of a solid material low in thermal conductivity or a gas regulated in temperature.

[Detailed description of the Invention]

[0001]

[Technical field to Which the Invention Belongs]

The present invention relates to a lithographic printer for use in transferring a mask pattern onto a photosensitive substrate in a lithography process to manufacture, say, a semiconductor device, a liquid-crystal device or a thin-film magnetic head, which more particularly is suited in use on a printer having a measuring instrument that measures an exposure beam state, an imaging characteristic or the like.

[0002]

[Prior Art]

In the manufacture of a semiconductor device or the like, the printer of the one-shot exposure type (stepper) conventionally is frequently used in the transfer process of an on-reticle pattern, as a mask, onto a resist-applied wafer (or a glass plate or the like) under the existence of predetermined exposure light. Recently, attentions are also drawn to such a scanning-exposure type projection printer (scanning printer) as of a step-and-scan scheme that performs a printing by synchronously scanning the reticle and the wafer relative to a projection optical system, in order to accurately transfer a reticle pattern having a great area without increasing the size of the projection optical system.

[0003]

Those printers are required to make a printing at a proper exposure and in a state maintaining the imaging

characteristics high. For this reason, a measuring instrument is provided on a reticle stage to align the reticle or on a wafer stage to align the wafer, in order to measure the illuminance state of exposure light, etc. and the imaging characteristics including projective magnification, etc. For example, the measuring instruments for provision on the wafer stage include an irradiation-dosage monitor that measures the incident energy of exposure light upon the projection optical system, a spatial-image detecting system that measures the position, contrast, etc. of a projection image. Meanwhile, the measuring instruments for provision on the wafer stage include, say, a reference plate formed with an index mark for use in measuring the imaging characteristics of the projection optical system.

[0004]

[Problem that the Invention is to Solve]

In the conventional printer like the above, exposure is kept properly while maintaining the imaging characteristics high, by use of the measuring instruments provided on the reticle or wafer stage. On the contrary, the recent printer is required to enhance the throughput (productivity) in the printing process, in the manufacture of a semiconductor device or the like. The throughput-improving methods include a method to increase the exposure energy per unit time. Besides, there is a method that the stage drive rate is increased to

reduce the stepping time for the one-shot exposure type and to reduce the time of stepping and scanning exposure for the scanning exposure type.

[0005]

In this manner, in order to improve the stage drive rate, it is satisfactory to use a drive motor having a greater output where the stage systems are in the same size. Conversely, in order to improve the drive rate by means of a drive motor equal in output to the conventional one, the stage systems must be reduced in size and weight. However, where using a drive motor having a high output as in the former case, there is an increase of the heat caused at the drive motor. The increasing amount of heat causes delicately a thermal deformation in the stage system, possibly making it difficult to obtain such a high alignment accuracy as required for the printer. Therefore, there is a desire to make the stage system smaller in size and lighter in weight to a possible extent as in the latter case, in order to prevent the deterioration of alignment accuracy and improve the drive rate.

[0006]

Particularly, the scanning-exposure type printer has the major advantage that the improvement of drive rate reduces the scanning exposure time and greatly improves the throughput while the size reduction of the stage system improves the synchronous accuracy between a reticle and a wafer, thereby

improving also the imaging characteristics and overlay accuracy. Nevertheless, there encounters a difficulty in size-reducing the stage where various measuring instruments are provided on the reticle or wafer stage.

[0007]

Furthermore, where the reticle or wafer stage has a measuring instrument that measures an exposure light state, an imaging characteristic or the like, the measuring instrument usually includes a heat source such as an amplifier wherein the temperature of the measuring instrument is increased gradually by the irradiation of exposure light during measurement. As a result, the reticle or wafer stage delicately deforms to possibly deteriorate the alignment accuracy, overlay accuracy, etc. In the present situation, the deterioration of alignment accuracy, etc. is less in extent on the measuring instrument. In the future, the measuring instrument is expectedly required to suppress the effect of temperature rise to a greater extent as the circuit pattern is downscaled furthermore for a semiconductor device or the like.

[0008]

The present invention is in view of the foregoing points, and it is a first object of the present invention to provide a printer that the reticle or wafer aligning stage can be reduced in size in the state maintaining the function to measure

the exposure light state or the imaging characteristics. The invention has a second object to provide a printer having a measuring instrument to measure the exposure light state or the imaging characteristics and capable of reducing the adverse effect of temperature rise upon making a measurement by use of the measuring instrument.

[0009]

[Means for Solving the Problem]

A first printer according to the invention is a printer that transfers a pattern formed on a mask (R) onto a substrate (W) by use of an exposure beam, the printer comprising: a first stage (RST, WST) that holds at least one of the mask and the substrate and moves a predetermined area; a second stage (5, 14) that is independent of the first stage; and a measuring instrument (6, 18) that is attached on the second stage and measures a state of the exposure beam.

[0010]

According to the invention, the first stage for use in printing in the nature is provided with a minimally required function for printing so that the first stage can be made in a minimally required size, thereby making it possible to make the stage smaller in size and lighter in weight. Meanwhile, the measuring instrument, for measuring the illuminance, etc. of an exposure beam without having a direct bearing on printing, is mounted on the separate second stage, thus being allowed

to measure also the state of an exposure beam.

[0011]

In this case, the measuring instrument is, say, a photoelectric sensor that measures the total power of an exposure beam, an illuminance-nonuniformity sensor that measures the illuminance distribution of such an exposure beam, or the like. Meanwhile, the second stage is, say, arranged to move independently of the first stage on the movement plane of the first stage. At this time, by arranging the second stage in place of the first stage, the state of an exposure beam can be measured in the vicinity of the plane where the substrate is actually put.

[0012]

Meanwhile, a control unit (10) is desirably included that causes the first stage to move between a position to which the exposure beam is to be irradiated and a position to which the exposure beam is not to be irradiated. At this time, during measurement, the first stage is retracted from the position where an exposure beam is irradiated. Meanwhile, a control unit (10) is desirably included that causes the second stage to move between a position to which the exposure beam is to be irradiated and a position to which the exposure beam is not to be irradiated. This allows the measuring instrument of the second stage moves to the position to which an exposure beam is to be irradiated.

[0013]

Meanwhile, a control unit (10) is desirably included that aligns the second stage in a position to which the exposure beam is not to be irradiated when the first stage is in a position to which the exposure beam is to be irradiated. This makes it possible to separately use the two stages with efficiency between during printing and during measurement. Next, a second printer according to the invention is a printer that projects a pattern formed on a mask (R) onto a substrate (W) through a projection optical system (PL), the printer comprising: a first stage (WST) that holds the substrate and moves a predetermined area; a second stage (14) that is independent of the first stage; and a measuring instrument (20) that is arranged on the second stage and measures an imaging characteristic of the projection optical system.

[0014]

According to the invention, the first stage for use in printing in the nature is provided with a minimally required function for printing so that the first stage can be made in a minimally required size, thereby making it possible to make the first stage smaller in size and lighter in weight. Meanwhile, the measuring instrument, for measuring the imaging characteristics such as distortion without the direct need for printing, is mounted on the separate second stage, thus being allowed to measure also the imaging characteristics.

[0015]

In this case, the measuring instrument is, say, a projection-image position sensor, a measuring index mark, a measuring reference plane or the like. Meanwhile, the second stage is, say, arranged to move independently of the first stage on the movement plane of the first stage. At this time, by arranging the second stage in place of the first stage, the imaging characteristics can be measured on the plane where the substrate is actually put.

[0016]

Meanwhile, a control unit (10) is desirably included that causes the first stage to move between a position within an exposure area due to the projection optical system and a position outside the exposure area. At this time, during measurement, the first stage is retracted from the exposure area. Likewise, a control unit (10) is desirably included that causes the second stage to move between a position within an exposure area due to the projection optical system and a position of outside the exposure area. At this time, during measurement, the measuring instrument of the second stage moves to the exposure area.

[0017]

Next, a third printer according to the invention is a printer that transfers a pattern formed on a mask (R) onto a substrate (W) by use of an exposure beam, the printer

comprising: a stage (41) arranged with a measuring instrument (18, 19) that measures a state of the exposure beam; and a cooling device (44, 45A, 45B) that is provided on the stage and cools the measuring instrument. According to the invention, even in case the measuring instrument is used and the temperature of the measuring instrument rises upon measuring the illuminance, etc. of the exposure beam, it can be cooled by the cooling device, thus exerting no effects of temperature rise to the exposure area.

[0018]

Next, a fourth printer according to the invention is a printer that projects a pattern formed on a mask (R) onto a substrate (W) through a projection optical system (PL), the printer comprising: a stage (41) arranged with a measuring instrument (20, 42, 43) that measures an imaging characteristic of the projection optical system; and a cooling device (44, 45A, 45B) that is provided on the stage and cools the measuring instrument. According to the invention, even in case the measuring instrument is used and the temperature of the measuring instrument rises upon measuring the imaging characteristics, it can be cooled by the cooling device, thus exerting no effects of temperature rise to the exposure area.

[0019]

Next, a fifth printer according to the invention is a printer that transfers a pattern formed on a mask (R) onto a

substrate (W) by use of an exposure beam, the printer comprising: a first stage (WST, 41A) that holds at least one of the mask and the substrate and moves across a predetermined area; a second stage (14, 41Aa) mounted with a measuring instrument (18, 19) that measures a state of the exposure beam; and a heat insulation member (48) that is arranged between the first stage and the second stage and cuts off heat conducting from the second stage. According to the invention, even in case the measuring instrument includes a heat source or the temperature of the measuring instrument rises upon measuring the illuminance, etc. of the exposure beam by use of the measuring instrument, the heat insulation member hinders the conduction of heat, thus exerting no effects of temperature rise to the exposure area.

[0020]

In this case, the heat insulation member is, say, of a solid material (48) low in thermal conductivity or a gas regulated in temperature. Such a gas regulated in temperature uses a gas air-conditioned or the like. Next, a sixth printer according to the invention is a printer that projects a pattern formed on a mask (R) onto a substrate (W) through a projection optical system (PL), the printer comprising: a first stage (WST, 41A) that holds the substrate and moves across a predetermined area; a second stage (14, 41Aa) mounted with a measuring instrument (20) that measures an imaging characteristic of the

projection optical system; and a heat insulation member (48) that is arranged between the first stage and the second stage and cuts off heat conducting from the second stage. According to the invention, even in case the measuring instrument is used and the temperature of the measuring instrument rises upon measuring the imaging characteristics or the measuring instrument includes a heat source, the heat insulation member hinders the conduction of heat, thus exerting no effects of temperature rise to the exposure area.

[0021]

In this case, the heat insulation member is, say, of a solid material (48) low in thermal conductivity or a gas regulated in temperature.

[0022]

[Mode for Carrying Out the Invention]

With reference to Figs. 1 to 4, explanation will be now made below on a first embodiment of the present invention. Fig. 1 shows a projection printer of a step-and-scan scheme to be used in the present embodiment. During exposure in Fig. 1, the exposure light IL, emitted from an illumination system 1, including an exposure light source, a beam-forming optical system, an illuminance-uniformizing fly's-eye lens, a light-amount monitor, a variable aperture stop, a field stop and a relay lens, illuminates a reticle R at its slit-like illumination area of a pattern surface (lower surface) thereof

through a mirror 2 and a condenser lens 3. As exposure light IL can be used excimer laser light, e.g. KrF (wavelength: 248 nm) or ArF (wavelength: 193 nm), YAG-laser higher harmonics, mercury-lamp at i-line (wavelength: 365 nm) or the like. By switching the variable aperture stop in the illumination system 1, illumination can be desirably selected to a scheme among the usual illumination, orbicular illumination, so-called modified illumination, illumination with a small coherent factor (σ value) and the like. Where the exposure light source is a laser light source, its emission timing, etc. is under control of the main control system 10 taking total control of the apparatus overall operation, through a laser power source, not shown.

[0023]

The pattern image of the reticle R, formed in an illumination area 9 (see Fig. 3) due to the exposure light IL, is reduced at a projective magnification β (β: 1/4 times, 1/5 times or the like) and projected to a slit-like exposure area 12 over a wafer W applied with photoresist. From now on, explanation is with a Z-axis taken parallel with an optical axis AX of the projection optical system PL, an X-axis taken along the non-scanning direction (i.e. direction vertical to the Fig. 1 page) orthogonal to the scanning direction of the reticle R and wafer W in scan exposure on a plane vertical to the Z-axis, and a Y-axis taken along the scanning direction

(i.e. direction parallel with the Fig. 1 page).

[0024]

In the outset, an alignment sensor 16 of an image-processing scheme is provided adjacent the projection optical system PL, according to an off-axis scheme for wafer-W alignment. The alignment sensor 16 has a detection signal that is supplied to an alignment processing system of the main control system 10. The alignment sensor 16 is used to detect the position of an alignment mark (wafer mark) formed on the wafer W. The spacing (baseline amount), between a detection center of the alignment sensor 16 and a center of a reticle-R projection image given by the projection optical system PL, is previously determined with accuracy and stored in an alignment processing system of the main control system 10. From the detection result of the alignment sensor 16 and the baseline amount thereof, alignment is accurately effected between a wafer-W shot area and a reticle-R projection image. Though not shown, a reticle-alignment microscope is arranged above the reticle R in order to detect the alignment mark on the reticle R.

[0025]

The reticle R is held on a reticle stage RST by vacuum clamp. The reticle stage RST is rested, moveable in the Y direction, over two guides 4A, 4B arranged parallel in the Y direction through bearings. Furthermore, in this embodiment,

a measurement stage 5 is arranged, movable in the Y direction and independently of the reticle stage, over the guides 4a, 4B through air bearings.

[0026]

Fig. 3 is a plan view showing the reticle stage RST and measurement stage 5. In Fig. 3, the reticle stage RST and the measurement stage 5 are rested along the guide 4A, 4B extending in the Y direction so that those can be each driven in the Y direction by means of a not-shown linear motor or the like. The guides 4A, 4B have a length set up longer by at least a width of the measurement stage 5 than the movement stroke of the reticle stage RST during scan exposure. Meanwhile, the reticle stage RST is structured by a combination of a rough stage to move in the Y direction and a fine stage that is adjustable finely in position two-dimensionally over the rough stage.

[0027]

On the measurement stage 5, there is fixed a reference plate 6 formed of a glass plate elongate in the X direction. On the reference plate 6, a plurality of index marks are formed in a predetermined arrangement in order to measure a imaging characteristics of the projection optical system PL. The reference plate 6 has a size to cover the slit-like illumination area 9 of exposure light to the reticle R, more specifically the projection optical system PL at its field-of-vision on a

side closer to the reticle R. The use of the reference plate 6 eliminates the need to prepare a reticle exclusive for imaging-characteristic measurement. Moreover, the exchange time is made unnecessary between the reticle R for actual printing and the exclusive reticle. This allows for frequent measurements of imaging characteristics, thus making it possible to correctly follow the change in time of the projection optical system PL.

[0028]

In this manner, the embodiment is independently provided with the measurement stage 5 for the reference plate 6 wherein no measuring members but the reticle R are mounted on the reticle stage RST itself. Namely, because the reticle stage RST is satisfactorily provided with minimally required scanning and alignment functions for scan exposure, the reticle stage RST is realized smaller in size and lighter in weight. Accordingly, because the reticle stage RST can be scanned at higher rate, throughput improves in the printing process. Particularly in the case of reduced projection, the scan rate of the reticle stage RST is given $1/\beta$ times (e.g. four times or five times) the scan rate of the wafer stage. Thus, the upper limit of scan rate possibly is nearly determined by the reticle stage, in which case throughput particularly is improved significantly in the present embodiment.

[0029]

Meanwhile, from a laser interferometer 7Y set up in a +Y direction relative to the guides 4A, 4B, a laser beam is irradiated to a movement mirror on a +Y-directional side surface of the reticle stage RST. From biaxial laser interferometers 7X1, 7X2 set up in a +X direction, laser beams are irradiated to a movement mirror on a +X-directional side surface of the reticle stage RST. The laser interferometers 7Y, 7X1, 7X2 measure the X and Y coordinates and rotation angle of the reticle stage RST, which measurement values are supplied to the Fig. 1 main control system 10. The main control system 10 takes control of the rate and position of the reticle stage RST through the linear motor, etc., depending upon the measurement values. Meanwhile, from a laser interferometer 8Y set up in a -Y direction relative to the guides 4A, 4B, a laser beam is irradiated to a movement mirror on a -Y-directional side surface of the measurement stage 5. The laser interferometer 8Y measures the Y coordinate of the measurement stage 5 that is supplied to the main control system 10. The Y-axis laser interferometers 7Y, 8Y have optical axes that respectively extend in the Y direction and pass the center of the illumination area 9, i.e. the optical axis AX of the projection optical system PL. The laser interferometers 7Y, 8Y both measure, at all times, the position of the reticle stage RST and measurement stage 5 in a scanning direction.

[0030]

During the measurement of imaging characteristics, in case the reticle stage RST is retracted in the +Y direction and the measurement stage 5 is moved in the Y direction in a manner the reference plate 6 covers the illumination area 9, the laser beams of from the laser interferometers 7X1, 7X2 are moved off the side surface of the reticle stage RST and illuminated to the movement mirror on the +X-directional side surface of the measurement stage 5. Depending upon the measurement value obtained from the laser interferometers 7X1, 7X2 at this time, the main control system 10 accurately controls the position of the measurement stage 5 through the linear motor, etc. Incidentally, on this occasion, in the case the reference plate 6 is desirably aligned more accurately with the illumination area 9, an alignment mark is satisfactorily formed on the reference plate 6 so that the mark can be detected in position by use of the reticle-alignment microscope.

[0031]

Meanwhile, during measurement, the reticle stage RS is not measured for the position in the non-scanning direction. However, when the reticle stage RST reaches the below of the illumination area 9 in order for printing, the laser beams of from the laser interferometers 7X1, 7X2 become irradiated again to the movement mirror of the reticle stage RST. Because the final alignment is by use of the reticle-alignment microscope, there are no inconvenient disconnections in the

laser beam of from the laser interferometers 7X1, 7X2.

[0032]

Referring back to Fig. 1, the wafer W is held on the wafer stage WST through a not-shown wafer holder. The wafer stage WST is arranged, for movement in the X and Y directions, upon the base 13 through an air bearing. The wafer stage WST is built therein with a focus-leveling mechanism taking control of the Z-directional position (in-focus position) and inclination angle of the wafer W. Meanwhile, separately from the wafer stage WST, a measurement stage 14 having a variety of measuring instruments is arranged upon the base 13 through an air bearing in a manner to move in the X and Y directions. The measurement stage 14 also is built therein with a mechanism taking control of an in-focus position on the upper surface thereof.

[0033]

Fig. 2 is a plan view showing a wafer stage WST and a measurement stage 14. In Fig. 2, a coil string is buried, say, in a predetermined arrangement in the interior of the base 13 with respect to the surface thereof. Magnet strings are buried, together with yokes, respectively in the bottoms of the wafer state WST and measurement stage 14. The coil string and the corresponding magnet string constitute a plane motor. By means of the plane motors, the wafer stage WST and the measurement stage 14 are independently controlled in X and Y

directional positions and rotation angle. Incidentally, such a plane motor is disclosed in greater detail in JP-A-H8-51756, for example.

[0034]

The wafer stage WST in the embodiment has the minimal functions required for printing. Namely, the wafer stage WST has a focus-leveling function. Moreover, on the wafer stage WST, there are fixed two members, i.e. a wafer holder (on wafer-W bottom side) to vacuum-clamp the wafer W and a reference mark plate 17 for use in measuring the position of the wafer state WST. A reference mark (not shown) is formed on the reference mark plate 17, to provide a positional reference in the X and Y directions. By detecting the position of the reference mark by means of the alignment sensor 16, the wafer stage WST (wafer W) is detected in its positional relationship, say, to a reticle-R projection image.

[0035]

Meanwhile, the measurement stage 14 has a surface set up nearly equal in height to the surface of the wafer W on the wafer stage WST. On the measurement stage 14, there are fixed a irradiation-dosage monitor 18 formed by a photoelectric sensor to measure the energy (incident energy) per unit time of the whole part of exposure light passed the projection optical system PL, an illumination-nonuniformity sensor 19 formed by a photoelectric sensor to measure the illuminance

distribution in the slit-like exposure area 12 given by the projection optical system Pl, and a measurement plate 20 formed with slits 21X, 21Y for use in measuring the imaging characteristics. A focus lens and a photoelectric sensor are arranged on the bottom side of each of X-axis and Y-axis slits 21X, 21Y of the measurement plate 20. The measurement plate 20, the photoelectric sensors, etc. constitute a spatial-image detecting system. Incidentally, rectangular opening edges may be used in place of the slits 21X, 21Y. The irradiation-dosage monitor 18 is formed with an imaging plane having a size covering the exposure area 12. The illuminance-nonuniformity sensor 19 has an imaging plane formed in a pinhole form. The irradiation-dosage sensor 18 and the illuminance-nonuniformity sensor 19 have detection signals to be supplied to the Fig. 1 main control system 10.

[0036]

Meanwhile, the photoelectric sensor, provided in the bottom of the measurement plate 20, has a detection signal to be supplied to the Fig. 1 imaging-characteristic operation system 11. In this case, during measuring the imaging characteristics of the projection optical system PL, the reference plate 6 on the measurement stage 5, closer to the Fig. 3 reticle, is moved to the illumination area 9. The index-mark IM image, formed on the reference plate 9, is projected toward the wafer stage. While scanning the image

in the X and Y directions by means of the slits 21X, 21Y of the measurement plate 20, the signal of from the photoelectric sensor in the bottom is fetched by means of the imaging-characteristic operation system 11. The imaging-characteristic operation system 11 processes the detection signal and detects the position and contrast of the index-mark IM image, and determines imaging characteristics, such as curvature-of-field, distortion and best-in-focus position, of the projection image from the detection result and outputs those to the main control system 10. Furthermore, though not shown, there is also provided a mechanism that drives a predetermined lens of the projection optical system PL and corrects a predetermined imaging characteristic, such as distortion. The main control system 10 is structured allowed to correct for the imaging characteristics of the projection optical system PL through the correction mechanism.

[0037]

In Fig. 2, the sensors, e.g. the irradiation-dosage monitor 18 and illuminance-nonuniformity sensor 19 and the photoelectric sensor at the bottom of the measurement plate 20 that are provided on the measurement stage 14, are each connected with a heat source, such as an amplifier, and with a power or communication signal cable. Accordingly, in case those sensors are mounted on the wafer stage WST for printing, alignment accuracy possibly deteriorates due to the heat

source or signal cable tension accompanied by the sensors. Meanwhile, the thermal energy of exposure light irradiation for measuring the imaging characteristics, etc., possibly incurs a worsening of alignment accuracy. On the contrary, in the present embodiment, such sensors are provided in the measurement stage 14 separated from the wafer stage WST for printing. Thus, there is a merit that the wafer stage WST can be reduced in size and weight wherein alignment accuracy can be prevented from lowering due to the thermal energy of from the heat sources of the measurement sensors or of the exposure light under measurement. By virtue of the size reduction of the wafer stage WST, the wafer stage WST is improved in moving rate and controllability, thus enhancing the throughput in the printing process and improving the alignment accuracy, etc. furthermore.

[0038]

Meanwhile, from the laser interferometer 15 arranged in the +Y direction relative to the base 13, a laser beam is irradiated to the movement mirror on the +Y-directional side surface of the wafer stage WST. From the biaxial laser interferometers 15X1, 15X2 arranged in the -Y direction, laser beams are irradiated to the movement mirror on the -X-directional side surface of the wafer stage WST. The wafer stage WST is measured in its X and Y coordinates and rotational angle by means of the laser interferometers 15Y, 15X1, 15X2,

which measurement value is supplied to the Fig. 1 main control system 10. Depending upon the measurement value, the main control system 10 controls the rate and position of the wafer stage WST through the plane motor. Meanwhile, during measuring the incident energy, etc. of exposure light, the laser beam for positional measurement is irradiated to the movement mirror of the measurement stage 14.

[0039]

Fig. 4 shows an arrangement example of the wafer stage WST and measurement stage 14 under measurement of incident energy, etc. of exposure light. As shown in Fig. 4, in case the wafer stage WST is retracted to a position separated from the exposure area 12 and the measurement stage 14 is moved in a manner the exposure area 12 is over the measurement stage 14, the laser beams from the laser interferometers 15Y, 15X1, 15X2 go off the side surfaces of the wafer stage WST into an illumination to the movement mirror on the side surface of the measurement stage 14. Depending upon the measurement value obtained at this time from the laser interferometers 15Y, 15X1, 15X2, the main control system 10 places the position of the measurement stage 14 under accurate control through the plane motor. Incidentally, because the wafer stage WST and the measurement stage 14 are also to be roughly controlled by driving the plane motor on an open loop, the main control system 10 drives the wafer stage WST and measurement stage 14 in

position according to an open-loop scheme in the state no laser beams are irradiated. However, besides the laser interferometers 15Y, 15X1, 15X2, a linear encoder, etc. may be provided to detect the position of the wafer stage WST and measurement stage 14 at a predetermined accuracy so that positional measurement can be made by using the linear encoder, etc. in the state no laser are irradiated.

[0040]

Referring back to Fig. 1, though not shown, on the side surface of the projection optical system PL, there is arranged an focal-point detecting system (AF sensor) of an oblique incident type that projects a slit image onto a plurality of measuring points on the surface of the wafer W and detects an in-focus position in the corresponding measuring point from a lateral deviation of the slit image refocused by the reflection light thereof. Depending upon the detection result of the focal-point detecting system, the wafer-W surface under scan exposure is focused on the image plane of the projection optical system PL. Incidentally, although omitted in Fig. 2, on the measurement stage 14, there is also mounted a reference member having a reference plane for detecting the in-focus position.

[0041]

Now explanation is made on the operation of the projection printer of this embodiment. At first, the amount

of exposure light IL incident upon the projection optical system PL is measured by use of the measurement stage 14 on the wafer-stage side. In this case, in order to measure the incident light amount in a state the reticle R is loaded, a printing reticle-R is loaded onto the reticle stage RST, in Fig. 1. The reticle R is moved to the illumination area of exposure light IL. Thereafter, as shown in Fig. 4, the wafer stage WST retracts, say, in the +Y direction over the base 13 and the measurement stage 14 moves toward the exposure area 12 due to the projection optical system PL. Thereafter, the measurement stage 14 is stopped in a position that the irradiation-dosage monitor 18, at its image plane, of the measurement stage 14 covers the exposure area 12. In this state, the amount of exposure light IL is measured through the irradiation-dosage monitor 18.

[0042]

The main control system 10 supplies the measured amount of light to the focus-characteristic operation system 11. On this occasion, the focus-characteristic operation system 11 is supplied also with the measurement value obtained by detecting a luminous flux obtained by branching the exposure light IL in the illumination system 1. Based on the two measurement values, the focus-characteristic operation system 11 calculates a coefficient for indirectly operating the amount of incident light upon the projection optical system

PL, from the light amount monitored in the illumination system 1. In this duration, a wafer W is loaded onto the wafer stage WST. Thereafter, as shown in Fig. 2, the measurement stage 14 retracts to a position separated from the exposure area 12, to move the wafer stage WST such that the wafer W, at its center, on the wafer stage WST comes in a position nearby the optical axis (exposure area 12 center) of the projection optical system PL. While the wafer stage WST is in a retraction, no laser beams are irradiated from the laser interferometers 15Y, 15X1, 15X2 as shown in Fig. 4 so that position control is performed, say, by driving the plane motor according to an open-loop scheme.

[0043]

Thereafter, when the measurement stage 14 retracts from the exposure area 12 and the laser beams of the laser interferometers 15Y, 15X1, 15X2 are started irradiated to the wafer stage WST, the wafer stage WST is brought under control in position depending upon the measurement values of the interferometers. Thereafter, by using the not-shown reticle-alignment microscope in the above of the reticle R, the reticle stage RST is driven in a manner bringing the positional deviation of between the predetermined alignment mark on the reticle R and the predetermined reference mark on the Fig. 2 reference mark member 17 to a predetermined target value, reticle-R alignment is effected. Nearly

simultaneously therewith, another reference mark on the reference mark member 17 is detected in position by the Fig. 1 alignment sensor 16 thereby correctly detecting the positional relationship (baseline amount) of the wafer stage WST relative to a reticle-R projection image.

[0044]

Then, by detecting the position of the wafer mark added on the predetermined shot (sample shot) area on the wafer W through the alignment sensor 16, each shot area on the wafer W can be determined for its arrangement coordinate. Thereafter, depending upon the arrangement coordinate and the known baseline amount of the alignment sensor 16, scan exposure is conducted while performing the alignment between the shot area to print of the wafer W and the reticle-R pattern image.

[0045]

During scan exposure, the reticle R is scanned at a rate VR in the +Y direction (or -Y direction) through the reticle stage RST relative to the exposure-light IL illumination area 9 (see Fig. 3) in Fig. 1, in synchronization with which the wafer W is scanned at a rate $\beta \cdot VR$ (β: projective magnification) in the -X direction (or +X direction) through the wafer stage WST relative to the exposure area 12. The reason the scanning is opposite in direction is that the projection optical system PL projects an inversion image. After completing the printing on one shot area, the next shot area is moved to the scan start

position by stepping of the wafer stage WST. From then on, printing is effected to the shot areas in order, according to the step-and-scan scheme. During the scan exposure, the measurement stage 14 on the wafer-stage side and the measurement stage 5 on the reticle-stage side are both retracted to the outside of the exposure area, as shown in Figs. 2 and 3.

[0046]

Meanwhile, during printing, the luminous flux branched from the exposure light IR is under measurement for light amount at all times, say, within the illumination system 1, into a supply to the imaging-characteristic operation system 11. The imaging-characteristic operation system 11 calculates the amount of exposure light IL entering the projection optical system PL depending upon the light-amount measurement value and the previously determined coefficient, and the change amount of imaging characteristics (magnification, distortion, etc.) through the projection imaging system PL caused due to the absorption of exposure light IL, thus supplying the result of calculation to the main control system 10. The main control system 10 corrects the imaging characteristic by driving, say, a predetermined lens of the projection optical system PL.

[0047]

The above is for the usual printing. When measuring for apparatus state in the maintenance of the printer of this

embodiment, measurement is made by moving the measurement station 14 toward the exposure area 12. For example, when measuring the illuminance uniformity within the exposure area 12, the reticle R is removed from the reticle stage RST and then illuminance distribution is measured while slightly moving the illuminance-nonuniformity sensor 19 in the X and Y directions within the exposure area 12. On this occasion, in case there is a need to determine the position of the measurement stage more correctly, a reference mark member corresponding to the reference mark member 17 may be provided on the measurement stage 14 similarly to the wafer stage WST so that the position of the reference mark within the reference mark member can be measured by the alignment sensor 16.

[0048]

Next, explanation is made on the operation of measuring the imaging characteristic of the projection optical system PL by use of the measurement stage 5 on the reticle-stage side and the measurement stage 14 on the wafer-stage side. In this case, in Fig. 3, the reticle stage RST retracts in the +Y direction and the reference plate 6 on the measurement stage 5 moves into the illumination area 9. At this time, because the laser beams in the non-scanning direction of from the laser interferometers 7X1, 7X2 are also brought into irradiation to the measurement stage 5, the measurement stage 5 can be aligned accurately depending upon the measurement value of the laser

interferometers 8Y, 7X1, 7X2.

[0049]

At this time, a plurality of index mark IM images are projected toward the wafer stage through the projection optical system PL, as already explained. In this state, the measurement stage 14 in Fig. 4 is driven to san the index-mark IM images in the X and Y directions by means of the slit of the measurement plate 20. The detection signal of the photoelectric sensor at the bottom of the measurement plate 20 is processed in the image-characteristic operation system 11, thereby determining the positions and contrasts of the images. Meanwhile, while changing the in-focus position of the measurement plate 20 by a predetermined amount a time, the positions and contrasts of the images are determined. From the measurement results, the imaging-characteristic operation system 11 determines the change amounts of imaging characteristics, such as best in-focus position, curvature of field and distortion (including magnification errors), of the projection image of through the projection optical system PL. The change amounts are supplied to the main control system 10. When the change amount is in excess of a permissible range, the main control system 10 corrects the imaging characteristics of the projection image system PL.

[0050]

In the above embodiment, the wafer stage WST and the

measurement stage 14 are driven over the base 13 by means of the plane motors, as shown in Fig. 2. However, the wafer stage WST and the measurement stage 14 can be structurally driven two-dimensionally by a combination of one-dimensional motors. For this reason, with reference to Fig. 5, explanation is next made on a second embodiment that drives the wafer stage and the measurement stage each by a mechanism as a combination of one-dimensional motors. In this embodiment, the invention is also applied to a projection printer of a step-and-scan scheme wherein, in Fig. 5, the parts corresponding to Figs. 1 and 2 are attached with the same references to thereby omit the detailed explanations thereof.

[0051]

Fig. 5(a) is a plan view showing a projection printer at its wafer-stage side in the present embodiment while Fig. 5(b) is a front view thereof. In Figs. 5(a) and 5(b), two X-axis linear guides 34A, 34B are arranged parallel along the X direction over a base 33 while a Y-axis linear guide 32, elongate in the Y direction, is arranged in a manner connecting between the X-axis linear guides 34A, 34B. The Y-axis linear guide 32 is to be driven along the X-axis linear guides 34A, 34B by means of a not-shown linear motor.

[0052]

Meanwhile, a wafer stage 31 and a measurement stage 35 are arranged, movable in the Y direction but independently from

each other, along the Y-axis linear guide 32. A wafer W is vacuum-clamped on the wafer stage 31 through a not-shown wafer holder. On the measurement stage 35, there are fixed are an irradiation-dosage monitor 18, an illuminance-nonuniformity sensor 19 and a measurement plate 20. A photoelectric sensor is built in the bottom of the measurement plate 20. In this case, the wafer stage 31 and the measurement stage 35 are rested, at bottoms, upon the base 33 respectively through air bearings so that the wafer stage 31 and the measurement stage 35 can be independently driven in the Y direction along the Y-axis linear guide 32 through a not-shown linear motor. Namely, the wafer stage 31 and the measurement stage 35 are driven two-dimensionally and independently of each other along the Y-axis linear guide 32 and X-axis linear guides 34A, 34B. In this embodiment, the wafer stage 31 and the measurement stages 35 are measured for two dimensional positions by means of quarter-axial laser interferometers similarly to the laser interferometers 7Y, 7X1, 7X2, 8Y on the reticle-stage side in Fig. 3. Depending upon the measurement result, the wafer stage 31 and the measurement stage 35 are placed under control in position and drive rate. The other structure is similar to the first embodiment.

[0053]

In this embodiment, when measuring the irradiation energy of exposure light or the imaging characteristic of

through the projection optical system, the wafer stage 31 retracts to a position spaced in a -Y direction relative to the exposure area of light so that the measurement stage can move to the exposure area. Meanwhile, during printing, the measurement stage 35 retracts to a position spaced in a +Y direction relative to the exposure area with exposure light. Thereafter, by stepping the wafer stage 31 in the Y direction, the shot area for printing on the wafer W is moved to a scan-start position relative to the exposure area. Then, the wafer stage 31 is moved at a constant rate in the Y direction along the Y-axis linear guide 32 thereby effecting a scan exposure to the shot area.

[0054]

As described above, this embodiment arranges the measurement stage 35 along the Y-axis linear guide 32 independently of the wafer stage 31. This structure eliminates the need to drive the measurement stage 35 upon driving in the scanning direction (Y direction) requiring the higher accuracy of stage control. Moreover, because the wafer stage 31 is made smaller in size and lighter in weight, scanning rate can be improved wherein improved is the synchronization accuracy, etc. in scan exposure. Meanwhile, because the measurement stage 35 is to be driven simultaneously in the non-scanning direction (X direction), the drive mechanism has an increased burden. However, control accuracy is not needed

so high in the non-scanning direction as compared to in the scanning direction, there is less effect of such an increase of burden. Furthermore, because the measurement stage 35 as a heat source is separated from the wafer stage 31, the wafer stage 31 is prevented from lowering in alignment accuracy.

[0055]

Incidentally, in this embodiment, a second Y-axis linear guide 36 may be arranged parallel with the Y-axis linear guide 32 and movable in the X direction as shown by the two-dot chain line in Figs. 5(a) and 5(b), to arrange the measurement stage 35 movable in the Y direction on the Y-axis linear guide 32. This improves the control accuracy upon driving the wafer stage 31 in the X direction.

[0056]

Meanwhile, although the first embodiment arranged the reticle stage RST and the measurement stage 5 along the same guides 4A, 4B as shown in Fig. 3, the reticle stage RST and the measurement stage 5 may be provided to move independently and two-dimensionally as on the wafer-stage side in Fig. 2. Furthermore, the embodiments each provided one wafer stage WST, 31 on which a wafer W is to be placed thereon, such wafer stages to place wafers W thereon may be provided in a plurality. In this case, a method can be employed that printing is performed on one wafer stage while measurement for alignment or wafer exchange is on the other wafer stage. Likewise, a plurality

of reticle stages to place reticles R thereon may be also provided on the reticle-stage side so that different reticles can be placed on the plurality of reticle stages and subjected to exposure, in order, at the same shot area over the wafer under different exposure conditions (in-focus position, exposure amount, illumination condition, etc.).

[0057]

With reference to Figs. 6 and 7, explanation is next made on a third embodiment of the invention. This embodiment is provided with a cooling device that cools the measuring instrument provided on the wafer stage wherein, in Figs. 6 and 7, the parts corresponding to Figs. 1 and 2 are attached with the same references to thereby omit the detailed explanations thereof. Fig. 6 shows a projection printer of the present embodiment. In Fig. 6, a wafer W is arranged on the side of the exposure area 12 of through the projection optical system PL. The wafer W is held on a wafer stage 41 through a not-shown wafer holder. The wafer stage 41 rests upon a base 13, in a manner to be driven in the X and Y directions, say, by means of a plane motor. Though not shown, the wafer stage 41 is built therein with a mechanism that controls the wafer-W in-focus position and inclination angle. Furthermore, the wafer stage 41 is built therein with a mechanism for measuring an exposure-light IL or image-characteristic, in a manner surrounding the wafer W.

[0058]

Fig. 7 shows a plan view of the Fig. 6 wafer stage 41. In Fig. 7, in the vicinity of a wafer W (wafer holder), there are arranged a reference mark member 17, an irradiation-dosage monitor 18, an illuminance-nonuniformity sensor 19, and a measurement plate 20 formed with slits 21X, 21Y. Meanwhile, in the vicinity of the irradiation-dosage monitor 18 on the wafer stage 4, a recess 47 is formed to set up a portable reference illuminometer. A reference illuminometer is set up in the recess 47 so that illuminance can be matched between different projection printers by measuring the incident energy of exposure light IL. Furthermore, on the wafer stage 41 at its one corner, a reference member 46 is fixed formed with a reference surface that provides a reference in flatness, etc. In the present embodiment, a cooling device is provided to cool the heat source of the measuring mechanisms.

[0059]

Namely, as shown in Fig. 6 partially broken away, a focus lens 42 and a photoelectric sensor 43 are arranged in a slit 21Y bottom of the measurement plate 20. Though not shown, the photoelectric sensor 43 is connected with an amplifier, etc. Accordingly, a cooling tube 44 is laid within the wafer stage 41 in a manner passing the vicinity of the photoelectric sensor 43. The cooling tube 44 is supplied with a coolant of low-temperature liquid from the external cooling device

through a greatly-flexible tube 45A. The coolant, passing the tube 45A, is returned to the cooling device through the greatly flexible tube 45A. Meanwhile, the cooling tube 44 passes also the vicinity of the irradiation-dosage monitor 18 and illuminance-nonuniformity sensor 19, the recess 47 for the reference illuminometer, the reference mark member 17 and the bottom of the reference member 46. In this embodiment, because the thermal energy of from the heat source of the measuring instrument amplifier, etc. is released through the coolant of the cooling tube 44, wafer-W alignment accuracy, etc. is not to be worsened by the thermal energy. Meanwhile, even where exposure light IL is illuminated to the irradiation-dosage monitor 18 or the illumination-nonuniformity sensor 19 during measuring the incident energy, etc. of exposure light IL, the illumination energy is released through the coolant of the cooling tube 44. Thus, wafer-W alignment accuracy, etc. is not to be worsened by the thermal energy.

[0060]

Incidentally, although this embodiment cooled the measuring instrument by use of the liquid coolant, cooling may be made by feeding, say, air-conditioning air intensively to a vicinity of the measuring instrument. Next a fourth embodiment of the invention is explained with reference to Fig. 8. This embodiments provides a heat-insulation member between the wafer arrangement area (first stage) and the

measuring-instrument arrangement area (second stage), on the wafer stage wherein, in Fig. 8, the parts corresponding to Fig. 7 are attached with the same references to thereby omit the detailed explanations thereof.

[0061]

Fig. 8 shows a wafer stage 41A to be driven in X and Y directions on the base, similarly to Fig. 7 wafer stage 41. In Fig. 8, the wafer stage 41A has an upper part that is divided as a measuring-instrument arrangement area 41Aa and the other area by means of a heat insulation member 48 formed of a material low in heat conductivity. The material low in heat conductivity uses a metal such as stainless steel, iron or brass, or ceramics, glass or the like. A wafer W is put on the latter area through a wafer holder (not shown) wherein a reference mark member 17 is arranged providing a positional reference. In the former measuring-instrument arrangement area 41Aa, arranged are a reference mark member 17A formed with a mark providing a positional reference, an irradiation-dosage monitor 18, an illuminance-nonuniformity sensor 19, a reference member 46 having a reference plane and a measurement plate 20 formed with a slit. Furthermore, a recess 47 is formed on the measuring-instrument arrangement area 41Aa in order to set up a reference illuminometer.

[0062]

Although the present embodiment uses the measuring

instrument of within the measuring-instrument arrangement area 41Aa during the measurement of exposure light or imaging characteristic, the thermal energy generated at the measuring-instrument, etc. does not easily diffuse toward the wafer W through the heat insulation plate 48. Thus, wafer-W alignment accuracy, etc. is not to be worsened by the thermal energy. Likewise, there is a merit that the illumination energy, given by exposure light during measurement, does not easily diffuse toward the wafer W through the heat insulation plate 48.

[0063]

Incidentally, the air-conditioned air, of between the wafer stage WST and the measurement stage 14, can be regarded as a heat insulation member also in a separated structure of the wafer stage WST and measurement stage 14, as shown in Fig. 2, for example. Meanwhile, on the reticle-stage side, a heat insulation member may be arranged between the region where to rest the reticle and the region where to arrange the measuring instrument.

[0064]

Meanwhile, although the embodiments applied the invention to the step-and-scan-schemed projection printer, the invention is applicable also to a one-shot exposure type projection printer (stepper) and to a proximity printer not using a projection optical system. Besides printers,

application may be to an inspection device or repair device that uses a stage to position a wafer or the like.

[0065]

In this manner, the invention is not limited to the foregoing embodiments but can be structured within the scope not departing from the gist of the invention.

[0066]

[Effect of the Invention]

According to the first and second printers of the invention, the second stage having the measuring instrument is provided independently of the first stage that moves the mask or substrate. Accordingly, there is an advantage that the stage for aligning the mask or substrate can be reduced in size and weight in the state maintaining the function to measure the state of an exposure beam (exposure light) and the imaging characteristics of the projection optical system. Therefore, the stages can be improved in controllability, to improve the throughput in the printing process. Moreover, the heat source, such as a photoelectric sensor or an amplifier, structuring the measuring instrument is separated from the printing stage, thus improving the overlay accuracy, etc. Particularly, in case the invention is applied to such a scanning exposure type of printer as of the step-and-scan scheme, the improvement of scanning rate greatly improves the throughput. Thus the effect of the invention is significant.

[0067]

In those cases, where the second stage is arranged to move independently of the first stage, the first stage is allowed to move to the measuring area swiftly. Meanwhile, where providing a control unit capable of causing the first stage to move at between a position (exposure area) to which an exposure beam is to be irradiated and a position (non-exposure area) to which an exposure beam is not to be irradiated, the first stage can be retracted swiftly during measurement.

[0068]

Meanwhile, where providing a control unit capable of causing the second stage to move between a position (exposure area) to which an exposure beam is to be irradiated and a position (non-exposure area) to which an exposure beam is not to be irradiated, the second stage can be retracted swiftly during printing. Meanwhile, where providing a control unit capable of aligning the second stage in a position to which an exposure beam is not to be irradiated when the first stage is in a position to which an exposure beam is to be irradiated, the two stages can be separately used with efficiency.

[0069]

Next, according to the third or fourth printer of the invention, because there is provided a cooling device that cools the measuring instrument, it is possible to relieve the

adverse effect of temperature rise encountered in measuring the state of an exposure beam or the imaging characteristic of the projection optical system, thus providing an advantage of improving the alignment or overlay accuracy. Meanwhile, according to the fifth or sixth printer of the invention, because there is provided a heat insulation member between the two stages, it is possible to relieve the adverse effect of temperature rise encountered in measuring the state of an exposure beam or the imaging characteristic of the projection optical system, thus providing an advantage of improving the alignment or overlay accuracy.

[0070]

Meanwhile, when the heat insulation member is of a solid material low in thermal conductivity, the two stages can be moved in one body. Meanwhile, when the heat insulation member is of a gas regulated in temperature, there is obtained also an effect of first-stage size reduction.

[Brief Description of the Drawings]

[Fig. 1] is a schematic structural view showing a projection printer in a first embodiment of the present invention.

[Fig. 2] is a plan view showing a Fig. 1 wafer stage WST and measurement stage 14.

[Fig. 3] is a plan view showing a Fig. 1 reticle stage RST and measurement stage 5.

[Fig. 4] is a plan view serving for explaining the case to measure the state of exposure light by use of the measurement stage 14.

[Fig. 5] (a) is a plan view showing a wafer stage and measurement stage of a projection printer in a second embodiment of the invention, and (b) is a front view of Fig. 5(a).

[Fig. 6] is a schematic structural view partly broken away showing a projection printer in a third embodiment of the invention.

[Fig. 7] is a plan view showing a wafer stage of the Fig. 6 projection printer.

[Fig. 8] is a plan view showing a wafer stage of a projection printer in a fourth embodiment of the invention.

[Description of Reference Numerals and Signs]

R reticle

RST reticle stage

4A, 4B guide

5 reticle-stage side measurement stage

6 reference plate

PL projection optical system

W wafer

WST, 31, 41, 41A wafer stage

10 main control system

11 imaging-characteristic operation system

13 base

14, 35 wafer-stage side measurement stage

17 reference mark member

18 irradiation-dosage monitor

19 illuminance-nonuniformity sensor

20 measurement plate

32 Y-axis linear guide

33 base

34A, 34B X-axis linear guide

48 heat insulation plate

[Fig. 1]

10. Main control system

11. Imaging-characteristic operation system

A. Scanning direction

[Fig. 3]

A. Scanning direction

[Fig. 5](a)

A. Scanning direction

[Fig. 8]

48. Heat insulation plate